AIRBORNE DEPLETED URANIUM PARTICLE DISPERSION AND HAZARD FROM INTAKE THROUGH INHALATION

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ABSTRACT

In this paper we present depleted uranium aerosols dispersion from cloud generating due DU munitions impact to hard target. For diffusion modeling it is used Gaussian puff trajectory model. It is shown that dispersion depend of meteorological conditions. Regardless to DU concentration distribution, the worst case scenarios for quantity of intake DU aerosols due inhalation was happened for bystanders that stay far from hit hard target: (1) about 250-550 m, during cloudy calm weather and (2) as far as 150 m, during clear sky about noon. Amount of intake of DU through inhalation, that is the most dangerous route of intake, can varied due to level of physical activity at one side and characteristics of aerosols and assumed meteorological scenario at the other.

Key words: depleted uranium, aerosol, respiration, dispersion

1 INTRODUCTION

It is confirmed that DU munitions was used by NATO alliance during the conflict in the period of March-June 1999. in the south parts of Republic of Serbia, Kosovo district and cape of Arza in Montenegrin coast. But, DU aerosol dispersion is still mystery:

- targets, their location and type of hitting stay unknown for long time
- local meteorological conditions in the moment of actions and in hours after are still inaccessible

It is approved that intake of aerosols by inhalation is the most dangerous route of entry for DU aerosols. Experiments due measuring DU aerosols dispersion through atmosphere is very expensive. According to literature data it have been performed several time since 1979 in USA.

It is unknown, that it was performed air sampling with the aim to determine DU aerosols particle size distribution and dispersion through atmosphere during the NATO bombing Yugoslavia.

Reconstruction of DU aerosol dispersion through air is possible. In this paper it is shown results of assessment of DU aerosols dispersion after hitting 30-mm penetrator, using mathematical diffusion model and hypothetical meteorological conditions.

2 OBJECTIVE

Logical circumstances in which DU material become aerosolized (Parkhurst, 1995):

Fire

- in a tank containing DU munitions or/and armor
- in vehicle or other structure hit by DU munitions
- in a ammunition storage area

Impact/perforation by DU

- at an armor target
- breaching a target containing DU munitions or armor
- otherwise disturbing with force DU penetrator or armor on ground

Explosion

- perforation into a vehicle carrying DU munitions that explode
- explosion in an ammunition storage area

If a great number of penetrates hit hard targets and become aerosols on impact, there is a risk of people inhaling airborne DU dusts if they are closed to the target at the time of attack (UNEP, 2001).

From literature it is clear that experiments were performed with different DU penetrators (30, 105 and 120 mm) in aim to determine: quantity of DU that oxidize, chemical composition of appeared DU compound, particle size distribution and fraction of particles <10 μm. Although there are attempting (DoD, 2000), it is very difficult to summarize result, due to contradictions. That is proved by the fact that in USA such kind of investigations is intensified.

Fetter & Hippel (1999.) found out according to results involving multiple munitions:

three fire tests , 10-35 % of DU mass was converted into oxide, up to 0.6 % mass oxide form aerosols, up to 0.07 % oxide mass was respirable, up to 7 % of aerosols was soluble - conclusion was that in 0.05 % of total mass of DU convert to respirable particles

five impact tests(complete, partial and no hard armored target), 3-70 % of DU mass was converted into aerosols, 1-96 % mass of aerosols was respirable, 17-43 % of respirable aerosols was in soluble chemical form - conclusion was that 20 % of DU mass converted to respirable aerosols in hard target impact, roughly 10 % because no more than half strikes hard target

3 MODEL

AEROSOL DISPERSION

Kinetic energy of a 30 mm Gatling gun DU penetrator (muzzle velocity is about 1000 m/sec) is equivalent to about 0.1 pounds of TNT(Fetter & Hippel, 1999). Church (1969.) gives empirical relationship for the height (m) and radius (m) of cloud formed by detonation of equivalent amount, W, (pounds) of TNT.

- Height of center of initial cloud

$$H = 76 \times W^{0.25}$$

- Radius of initial cloud

$$R = 35 \times W^{0.375}$$

That is model used for calculation initially distributed aerosols throughout cloud generated by impact.

For the impact, perforation, or explosion scenario, the dispersion model throughout atmosphere should be Gaussian "puff" trajectory model:

$$C(x,y,z,t) = \frac{q}{\sqrt{(2\pi)^3}\sigma_x\sigma_y\sigma_z} \exp\left\{-\left[\frac{(x-ut)^2}{2\sigma_x^2} + \frac{y^2}{2\sigma_y^2}\right]\right\} \times \left\{\exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right] + \exp\left[\frac{(z+H)^2}{2\sigma_z^2}\right]\right\}$$

ut cloud - hit target distance in wind direction after t

σ_i standard deviation, function of ut

It is suppose uniform: particle size distribution and terminal velocity $V_{s.}$

$$H(t+\Delta t) = H(t) - (V_s \times x) / \Delta$$

ASSESSMENT - EXPOSURE & INTAKE

$$\mathbf{I(\mu g) = C \times MV \times t_{exp} \times RF}$$

where I - quantity of DU intake by inhalation (μg); C - concentration ($\mu g\ m^{-3}$); MV - minute volume ($m^3\,s^{-1}$); $t_{exp\,-}$ - exposure duration (min); RF - aerosol respirabile fraction

4 ASSUMPTIONS

AEROSOL DISPERSION

- worst case scenario
- 70 % of 30 mm Gatling gun DU penetrator converted to aerosols, 96% to respirable aerosols
- initial cloud height is 43 m , diameter 15 m
- DU aerosols particle size distribution uniform, diameter d_{DU}=0.5μm, terminal velocity v_s=0.0082 ms^{-1}

INTAKE

minute volume for light physical activity 20 l min^{-1} , $3.3\times10^{-4} m^3 s^{-1}$ (Silverman et all,1951.)

5 RESULTS AND DISCUSSION

According to results that are shown in figures 1-6, zone with maximal concentrations is in the height of initial cloud center. Concentrations near the ground, that are important for effects due inhalations are different.

For the attacks with DU munitions that happened during clear sky about noon, maximal concentration would be near the hit target (atmospheric meteorological category A).

During neutral stability (D), when sky is covered with low height clouds without wind, zone with maximal concentrations near the ground are 150-450 m far from hit target.

During stabile atmospheric condition (F) , for clear sky - night without wind, maximal concentrations near ground concentration are 200-700 m far from hit target.

Worst case scenarios for quantity of intake DU aerosols due inhalation was happened for people that stay outside far from hit hard target:

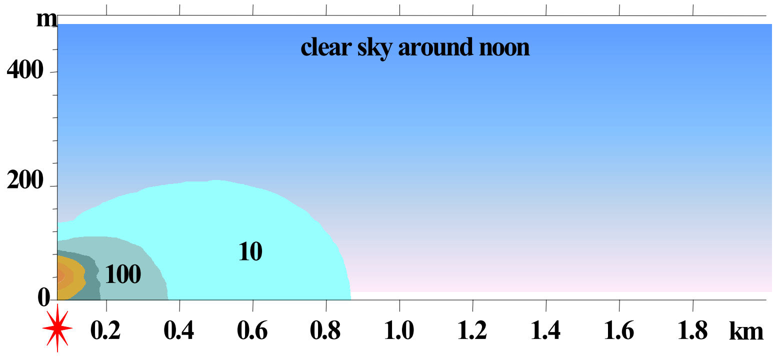


Figure 1. Average minute DU concentrations , atmospheric stability category A-very unstable, v=1ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}

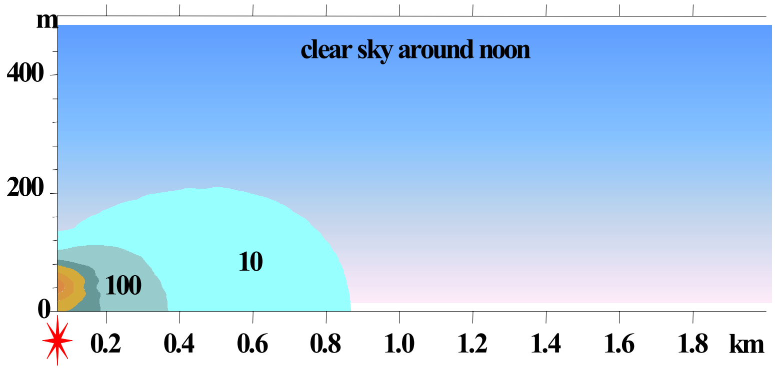


Figure 2. Average minute DU concentrations , atmospheric stability category F-very stable, v=1ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}

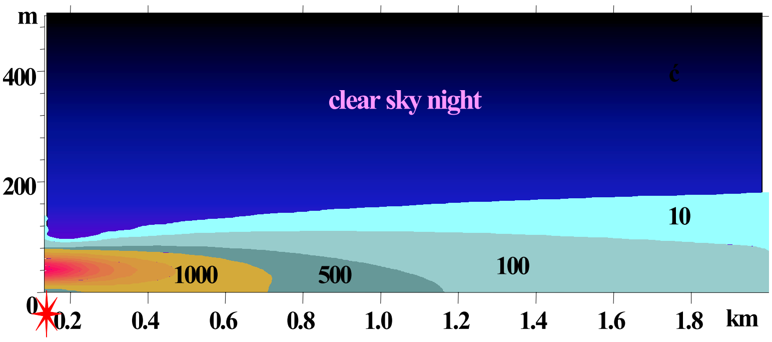
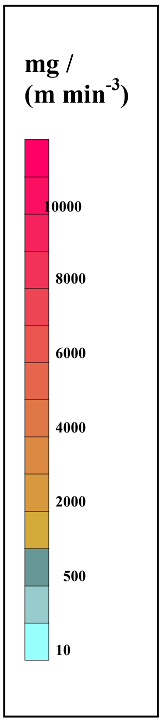


Figure 3. Average minute DU concentrations , atmospheric stability category D-neutral , v=1ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}



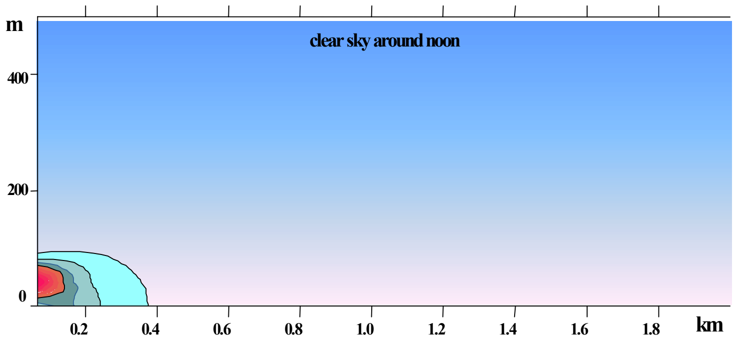
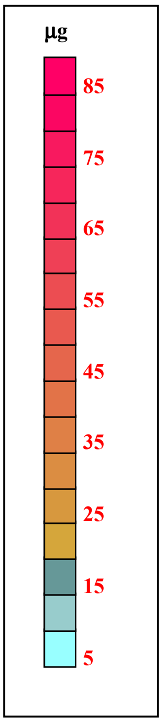


Figure 4. Quantity of intake DU by inhalation , atmospheric stability category A-very unstable, v=1 ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}



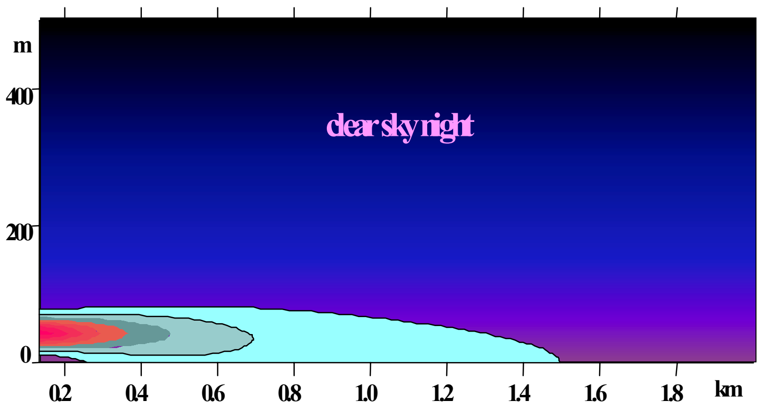


Figure 5. Quantity of intake DU by inhalation , atmospheric stability category F-very stable, v=1ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}

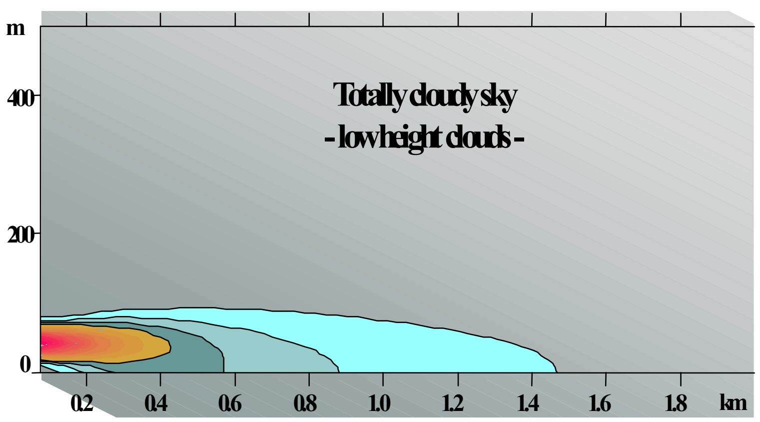


Figure 6. Quantity of intake DU by inhalation , atmospheric stability category D-neutral, v=1ms^{-1}, d_{DU}=0.5 µm , v_s=0.0082 ms^{-1}

- about 250-550 m, during cloudy calm weather (10/10 low cloud) without wind (Fig. 6.)
- as far as 150 m , during clear sky about noon (Figure 4.)

Quantity of inhaled DU aerosols depend also of physical activity of people for the period of cloud with DU aerosols pass over them. For rest minute volume of man male adults is about 15 $l \times min^{-1}$ and extremely hard physical activity about 75 $l \times min^{-1}$. Range of inhaled DU aerosols in soluble or insoluble form depend 6 times.

These simulations are performed for one piece of 30 mm Gatling gun DU penetrator. On assumption that duration of attack on one target last only one second, about 60 projectiles would be used, velocity is 3900 projectiles/minute (Žakula, 2001).

6 CONCLUSION

Objective answer about effect of consequences of DU munitions application on territory of FR Yugoslavia during conflict with NATO, would be done by reconstruction of dispersion DU aerosols through atmosphere in the period immediate after attack and next few hours ("hot faze"), for which would be need meteorological data that are inaccessible or nonexistent.

Inhalation is the most dangerous route of intake of DU. Quantity of intake DU aerosols depends of several factors including type of target, atmospheric meteorological conditions, physical activity of people that were under exposure during and immediately after attack. According to results of our simulation for, 30-mm Gatling gun DU penetrator that hit hard armored target, it is shown hazard for bystanders of exposure and intake of DU aerosols due different meteorological conditions and distance of hit target.

7 LITERATURE

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